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PORTO RICO AGRICULTURAL EXPERIMENT STATION,

MAYAGUEZ, P. R.

D. W. MAY, Agronomist in Charge.

**Under the supervision of the STATES RELATIONS SERVICE,
Office of Experiment Stations, U. S. Department of Agriculture.**

REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION.

1921.



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PORTO RICO AGRICULTURAL EXPERIMENT STATION.

[Under the supervision of the States Relations Service, United States Department of Agriculture.]

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LETTER OF TRANSMITTAL.

PORTO RICO AGRICULTURAL EXPERIMENT STATION,
Mayaguez, P. R., October 25, 1921.

SIR: I have the honor to transmit herewith and to recommend for publication a report of the Porto Rico Agricultural Experiment Station, 1921.

Respectfully,

D. W. MAY,
Agronomist in Charge.

Dr. A. C. TRUE,
*Director, States Relations Service,
U. S. Department of Agriculture, Washington, D. C.*

Publication recommended.

A. C. TRUE, *Director.*

Publication authorized.

HENRY C. WALLACE,
Secretary of Agriculture

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REPORT OF THE PORTO RICO AGRICULTURAL EXPERIMENT STATION, 1921.

REPORT OF THE AGRONOMIST IN CHARGE.

By D. W. MAY.

INTRODUCTION.

During the fiscal year 1921 agricultural production in Porto Rico showed a phenomenal increase, the money value of which has seldom been equaled on another area of the same size in so short a time. The annual exports of the island have steadily grown from around \$8,000,000 in 1901 to \$151,000,000 in 1921—a figure which is so extraordinary as to seem almost incredible. Porto Rico has a population of 377.8 per square mile, and it is now one of the most densely inhabited regions of the world. The island has no large cities which are supported by manufacture and its people are largely dependent upon agriculture for a livelihood. The future of Porto Rico is contingent upon the energy of its people, but the island should continue to flourish, since it is at the gate of the best markets of the large eastern cities of the States, has a low freight rate, and is free from duty.

SUGAR.

While general conditions regarding crop production were good during the year, all lines of agriculture were somewhat affected by the fall of prices from abnormal levels. Sugar fell from 24 to 4 cents a pound within the short space of 12 months. Unfortunately, very little attention was given to the production of other crops during the period when sugar was bringing high prices, and cane plantings were extended to lands that do not produce sugar at a profit in normal times. The cost of labor and materials increased with the price of sugar, and while the increase in wage undoubtedly did benefit the laboring classes it resulted in heavy losses for the plantation owners, the majority of whom had to face the problem of harvesting the crop at a value below the cost of production when the price of sugar fell.

As a result of the decline in price, it is likely that the plantation owners will begin to develop the other agricultural industries of the island. The station has repeatedly emphasized the necessity of diversifying agriculture in Porto Rico and with this purpose in view

has introduced and promoted the production of many new and promising crops. It is only by continued losses, however, that the planters can be made to realize the necessity of practicing a rotation which will result in the production of many foodstuffs for a number of years instead of growing a single remunerative product for the present.

As an outcome of the change in economic conditions, many of the lands that are not well adapted to cane will go back to pasture, with a resultant increase in the production of live stock, and the difficulty of feeding the ever-increasing population doubtless will be considerably lessened by the growing of crops which will constitute a balanced diet for human beings. A forced rotation is better than none at all, and it should prevent the loss which annually occurs wherever land is kept continuously in cane cultivation.

To safeguard the sugar industry, it is suggested that Porto Rican farmers continue to seek high-yielding varieties of cane that are immune to disease, plant legumes that will lessen the cost of fertilizers, practice a system of rotation, and use better methods of cultivation and up-to-date machinery to keep down the growing cost of labor.

During the year it was noted that cultural methods in cane production continued to improve, with better preparation of the land and the cultivation of the growing crop and that costs were materially reduced on plantations where up-to-date machinery had been installed. The mottling, or mosaic, disease of cane was less threatening this year than in former years. The control was partly due to the disease having run its course and partly to the elimination of diseased canes and the growing of immune or apparently immune varieties of cane.

At the station the major experimental work was confined to the breeding of new varieties of cane, demonstrating the value of cultivators, especially of the disk type, and the rotating of canes with legumes.

ANIMAL INDUSTRY.

Cattle.—The cattle generally found in Porto Rico are doubtless descendants of some that were brought from Spain in the early days following the discovery of the island. Until within the last few years no attempt was made to improve these cattle either by the importation of new breeds or by the judicious selection of the native cattle. Yet, notwithstanding these facts, the native cattle of Porto Rico are a strong race of good conformation, and make excellent work animals.

An earnest effort is now being made in Porto Rico to improve the cattle of the island, and the introduction of purebred animals from

the North will doubtless continue to increase as the cattle tick (*Margaropus annulatus*) is brought under control. The station does not recommend the importation of purebred stock by the general stock farmer until greater progress has been made in eliminating the cattle tick, or at least until the farmer is prepared to give introduced cattle good stabling, feed, and grooming.

A decrease in cane growing in Porto Rico will result in an increase in live-stock production. As one industry declines the other advances. Cattle are the main motive power used in cane growing. They are used to break the ground, to cultivate the cane, and to haul it from the field. When the cultivation of cane fields ceases the lands go back to pasture and are then employed in the raising of cattle.

The introduction by the station of certain forage crops has given a great impetus to cattle raising. Animals can not be expected to yield a profit unless they are given plenty of nutritious food. In raising cattle one should remember to breed for quality and to feed for quantity. Since the common grasses, and even the cultivated grasses, do not contain sufficient nourishment for stock, they should be supplemented with leguminous plants or grains having a high protein content. The station has found the velvet bean and the *Crotalaria* to make excellent feeds for cattle and valuable green-manure crops for the soil. Napier or elephant grass (*Pennisetum purpureum*) (Pl. I, Fig. 1) is so far the best of the introduced grasses for live stock. Guatemala grass (*Tripsacum laxum*) does very well on dry land (Pl. I, Fig. 2). A pasture grass (*Polytrias præmorsa*) from Java has been found promising not only for grazing purposes but also for ornamental purposes. It is a low creeping grass and has a better color than have the native grasses.

Dairying.—The output of milk per native cow is low. In a study made by the station to ascertain the quantity of milk yearly given by the native cow, it was found that 324 head averaged 6.47 pounds per day per cow. During the eight months the records were kept the average yield per cow was 1,552.8 pounds, or at the rate of 2,329.2 pounds per annum.

The station keeps two purebred Guernsey bulls of good stock for the herd, which was started some years ago with native cows. The animals now milked are three-fourths to seven-eighths purebred. The influence of the station bulls is shown in the improved quality of the dairy cows in the community. The improvement of yields in the station cows by crossbreeding is very noticeable. In the station herd, the native cows yielded an average of 8.09 pounds of milk per day, the half-bred cows (Pl. II, Fig. 1) 11.9 pounds, and the three-quarters-bred cows (Pl. II, Fig. 2) 13.5 pounds. This shows an increase of 47 per cent for the half-breeds over the native, and 13½ per cent gain for the three-quarters-bred over the half-bred.

It was noted during the year that methods of dairying were improving throughout the island. The improved methods are deserving of careful consideration, because upon them depends the quantity of milk delivered at each milking and the maintenance and uniformity of the milk flow.

Horses.—In Porto Rico little interest is taken in horse breeding. In the smaller towns horses are used to draw carriages and coaches and in the country districts they are saddle bred. The horse has never been used to any extent in Porto Rico as a draft animal, being replaced in this regard by cattle, and for transportation purposes by the automobile.

Swine.—Pigs are raised in small lots on the plantations and usually singly by the laborers. These animals are largely employed as scavengers and can not be improved or raised in greater numbers until a larger amount of feeds is produced for their maintenance.

Goats.—Some improvement is being brought about with goats, "the poor man's cow," by the introduction of better sires and by careful selection in breeding. There is room for improvement in this line of live-stock production in Porto Rico. The goat is adapted to the use of families who find it impossible to keep a cow because of limited space or an insufficient supply of food for the larger animals.

A goat will lower the cost and enlarge the supply of milk for the small farmer. One good milker will furnish an average family with a fine quality of milk for the greater part of the year. Three quarts a day is thought to be indicative of a good animal. Six or eight does can be kept on the amount of feed that is required for one cow. The marks and conformation which distinguish a good cow also appear in a good goat.

Poultry.—The Game is a breed which still predominates in Porto Rico. There is, however, a growing interest in the utility breeds, and many new fowls are being annually imported into the island. Of the introduced breeds, the Leghorns and the Plymouth Rocks are found in the greatest numbers. The production of chickens should be more general than is now the case. The number of domestic fowls in Porto Rico is very small when one considers the place that eggs and poultry should occupy in the diet of the million and a quarter people on the island. Notwithstanding the fact that poultry products bring relatively high prices in Porto Rico throughout the year, the farmers do not produce enough of them to supply the local demand, and refrigerated poultry is continually being brought in from the States for food, and eggs for breeding purposes. The small eggs of the native hen are usually higher in price by weight and even sometimes by the dozen than are the eggs which are imported from the North.



FIG. 1.—ELEPHANT OR NAPIER GRASS GROWING ON CUT-OVER LAND.



FIG. 2.—GUATEMALA GRASS AT STATION.



FIG. 1.—STATION COW, ONE-HALF GUERNSEY, ONE-HALF NATIVE.



FIG. 2.—STATION COW, THREE-FOURTHS GUERNSEY, ONE-FOURTH NATIVE.

In the rural districts there is enough feed growing around the small homes to support at least a few hens, and additional feeding crops can be grown if needed at almost any season of the year. Nevertheless many of the small farmers and a large number of the farm laborers do not own domestic fowls of any kind. The only way to remedy this state of affairs is to give constant and unremitting instruction on poultry in the rural schools and by agricultural agents.¹

Advice with reference to animal production.—The station will be glad to assist the farmer to solve the many problems which daily confront him in connection with the care, feeding, and breeding of stock. The farmer should clearly state the kind of stock to be fed, the place whence the feed is obtained, and the price paid for it. Home-grown feeds should be given the preference over imported feeds. The station will gladly outline a feeding plan to suit each case, and state the amounts and proper mixtures to be fed, so that the best results may be obtained at the lowest cost. The rations should be made attractive and palatable to the animal. Information regarding the care and breeding of animals can be had upon application to the station.

REFORESTING.

The station has continued in its efforts to impress upon the local public the necessity of protecting and developing the insular forests, and it has encouraged the growing of choice varieties of fruit-bearing trees, and especially those having a high food value. Improved varieties of guavas were propagated and widely distributed during the year. Thousands of ornamentals also were sent to all sections of the island. Plantings, especially of cabinet woods, were again made on the Mesa, above Mayaguez. (Pl. III, Fig. 1.) Among the introduced fruits on this mountain was the avocado, which seems to do better at this location than on the lowlands of the station. *Spathodia campanulata*, which is a handsome tree and makes quick growth, is being recommended for street planting.

DISTRIBUTION OF SEEDS AND PLANTS TO STATE STATIONS.

During the year some promising tropical plants were sent to the experiment stations of the Southern States, and seed of *Crotalaria juncea* was sent to the stations south of the Ohio River and along the Pacific coast, with the recommendation that the latter plantings be used as a cover crop. The *Crotalaria* makes such a quick growth, flowering in two months and ripening in three, that it apparently would do well in a small-grain rotation in the North if it were sown

¹ During the year the station issued a circular on poultry keeping in Porto Rico (Porto Rico Sta. Circ. 19), copies of which may be had by addressing the agronomist in charge.

after wheat, oats, or rye has been harvested. Very favorable reports concerning it have been received from several of the State stations.

HOW THE STATION REACHES THE PEOPLE OF PORTO RICO.

The station keeps in touch with the people in all parts of Porto Rico (1) by means of its publications, (2) by Agricultural Extension Notes which are mimeographed on the island, (3) by having members of the staff visit the various sections of the island, (4) by having those of the people who can do so visit the station, and (5) by correspondence.

The publications, which are printed at Washington, are regularly distributed to those whose names appear on the station's mailing list and will be sent to anyone else who is interested in the work of the station. These publications include annual reports, which keep the people advised regarding the progress of work from year to year, and bulletins and circulars which deal in detail with some particular feature of the work of the station. All of these publications are issued free of charge.²

Agricultural Extension Notes contains from 800 to 1,000 words, and are frequently distributed in both the English and the Spanish languages. These notes are issued twice a month and greatly facilitate the work of getting timely information before the people, especially those of the rural districts. The notes are distributed by mail and through the school children to people to whom mail is never delivered. By means of Agricultural Extension Notes the small farmer receives rudimentary information concerning agriculture, the benefit of the results of many and varied experiments conducted by the station, and valuable data that are obtained from other tropical experiment stations.

Correspondence is carried on with anyone who wishes information pertaining to the station or to any feature of the island's agriculture. The aim of the station is to benefit all who are engaged in or dependent upon any phase of agriculture in Porto Rico.

NEEDS OF THE STATION.

During the year three frame dwellings were erected at the station for members of the staff and their families (Pl. III, Fig. 2). The dwellings were constructed from two warehouses which were transferred by the War Department from the Army camp, Las Casas, at San Juan. These houses will supply the urgent needs of the station personnel.

The rainy season in Porto Rico begins in the spring and continues until autumn, when the trade winds shift rather suddenly and the

² Copies of all available publications issued may be had by writing to the agronomist in charge of the station.

dry season sets in and lasts throughout the winter. During the dry season vegetative growth is greatly hampered by the lack of moisture, and in some instances the crops are lost and the regular follow-up work in plant breeding is broken. In former days there was installed at the Hacienda Carmen, where the station is now located, an irrigation system which conducted water from the River Yaguez, bordering the grounds on the south. The water rights still pertain to the property, but funds are needed to put the system in condition to distribute water to all the lowlands of the station. Such a system would greatly enhance the extent and effectiveness of the work of the station.

The station also needs a reasonable appropriation to carry on a campaign for the eradication of the cattle tick which prevails throughout the island. The first dipping vat in Porto Rico was erected at the station and it has been followed by the construction and operation of dipping tanks in all sections of the island. The people have begun to recognize the importance of eliminating the tick and some of them have constructed dipping vats for their cattle. A systematic campaign to dip all infested stock at regular intervals is needed to insure the destruction of the tick, and the expenditure of a reasonable sum for this purpose would yield a great return to the cattle raisers and general stock farmers of Porto Rico.

REPORT OF THE CHEMIST AND ASSISTANT CHEMIST.

By L. G. WILLIS and J. O. CARRERO.

RICE INVESTIGATIONS.

Investigations which have been in progress at the station for several years to determine the effect of different fertilizers on rice production were brought to completion during the year.

Contrary to the findings of other investigators, it was found (1) that rice does not differ physiologically from most plants of agricultural importance in its response to fertilization with nitrogen in the form of nitrates; and (2) that as good results as, or even better than, those obtained from the use of ammonium sulphate can be had from the use of nitrate fertilizers if other factors are not permitted to influence the growth of the plant. In general practice, however, it might be well to continue the use of ammonium sulphate as a fertilizer on account of the susceptibility of nitrates to loss from leaching or denitrification when they are used under conditions that are peculiar to rice culture. From the results obtained at the station it is concluded that nitrate nitrogen, or any of the nitrogen products into which it may be converted in the soil, is not toxic or incompatible to the rice plant.

Reports of rice fertilization tests in the field are very contradictory. In some cases it appears that nitrates considerably increased the amount of plant growth; in others they exerted no appreciable, if any, benefit, and in a few tests they evidently had a harmful effect on the plant. Similarly, in the work of which this is a report, nitrate of soda proved as valuable a source of nitrogen as sulphate of ammonia on a red clay soil when loss by drainage was eliminated; but the average result of all tests was definitely in favor of sulphate of ammonia on a sandy soil, alkaline with carbonate of lime, compared with any form of nitrate used.

When a nitrate was used as a fertilizer in the sandy soil the plants germinated and grew normally until the appearance of the fourth leaf, after which the new leaves invariably showed signs of chlorosis, a condition which may be remedied to some extent by spraying the plant with a solution of ferrous sulphate or other iron salt. When the plants were not sprayed, the chlorosis usually followed one of two courses; either it became more intense until the bud apparently died or, as is often the case, the plants continued to grow, putting out pale greenish yellow, or striped yellow and green, or very finely mottled, leaves until they reached a stage in their growth at which all their new leaves were of a uniform deep green. They then became very thrifty and, heading normally, produced numerous well-developed panicles of grain.

In so far as chlorosis is concerned, the facts cited closely agree with the results obtained by P. L. Gile and J. O. Carrero³ in their study to determine the cause of lime-induced chlorosis of rice.

During the year a study was made to ascertain whether or not the unfavorable action of nitrate fertilizers on rice, as reported by some investigators, is due to the effect of the unassimilated residues of the physiologically alkaline salts on the availability of iron in the soil. The results obtained indicate that this is probably the case since, in an experiment in which chlorosis was largely controlled, all comparisons between nitrate of soda and sulphate of ammonia showed that nitrate nitrogen is at least equal to ammonia nitrogen for the fertilization of the rice plant.

An examination of some of the results obtained in the tests of nitrogenous fertilizers for rice leads to the belief that chlorosis, due to a lack of assimilable iron, occurs only on certain soils and under definite conditions. On the red soil above mentioned, chlorosis did not follow treatments with hydrated lime in any amount up to 5 per cent, neither did it occur at any degree of alkalinity up to pH 8.7, nor with any form of nitrate or ammonium salt used as a

³ U. S. Dept. Agr., Jour. Agr. Research, 20 (1920), No. 1, pp. 33-62, pl. 6.

fertilizer. On the sandy soil, naturally alkaline with carbonate of lime, however, chlorosis followed the application of certain fertilizers.

It was observed on the sandy soil that chlorosis invariably followed applications of nitrates or of ammonium phosphate in sufficient amount to supply enough nitrogen for thrifty plant growth. This observation leads to the belief that the development of lime-induced chlorosis of rice and possibly of other plants in calcareous soils is governed, not by the precipitation of the iron in the soil by the lime, but by the kind of fertilizer salts that are used and the nature of their unassimilated residues. Since the concentration of these residues is greatest at their source, it is evident that the growing plant modified the condition of equilibrium in the soil. The only true medium in which the plant grows is that part of the soil that is in actual contact with the plant root and is subject to its dynamic influence.

MANAGEMENT OF CANE SOILS.

The study of nitrogen economy in cane soils was continued according to the plan outlined in an earlier report,⁴ but no quantitative results were obtained owing to the nature of the investigations. Evidently a large amount of supplementary work must be done in connection with the experiments before determination can be made of the most suitable leguminous green-manure crop to use in cane rotation, the best time to plant this crop, and the most advantageous stage at which to plow it under. Apparently, also, moisture conservation is a matter of great importance, and the relation of green manuring to the water economy of the soil will have to be considered.

MISCELLANEOUS ANALYTICAL WORK.

During the year approximately 150 seedling canes were analyzed by the station. The policy of testing and analyzing materials that were sent in from various sources was continued, the work being done free of charge in every case where the results were thought to be of general agricultural interest. Many soils were likewise submitted for testing to determine their fertilizer requirements, but the station found it impossible to supply the information desired, except in a very general way. More complete knowledge is needed regarding the fertilizer requirements of the different soils of the island and the adaptability of different cultural methods to the various crops.

⁴ Porto Rico Sta. Rpt. 1919, p. 14.

REPORT OF THE HORTICULTURIST.

By T. B. McCLELLAND.

LEGUMES.

The third year of the variety test of beans was completed in 1921. On account of the present poor irrigation facilities, the test is limited to only one annual planting, when a full crop is desired. The planting of the third season again demonstrated the superiority of the varieties collected in the Caribbean region over the varieties commonly grown in and imported from the North. Of the Caribbean sorts, the black and the white beans were the most prolific, while of the northern varieties, Extra Early Valentine, Fordhook Favorite, and Robust made the largest yields.

The station made two extensive plantings of selections from the black Venezuelan bean to obtain, if possible, a type which will be as prolific as the Venezuelan and of a color that will be acceptable to the local market. The black bean, although a heavy yielder, is sold on the Porto Rican markets at a greatly reduced price on account of its color.

Comparative studies of several cover crops are in progress. The bush velvet bean never makes the growth at this station that it is reported to make on the mainland. It covers the ground for a much shorter period than do the twining varieties and matures its seed in the time of heavy rains if it is planted at the season for most favorable growth. The seeds are borne so near the ground that they are continually spattered with mud and water, which causes them to sprout before they can be picked. For this reason it is difficult to obtain seed for future plantings. The twining sorts are best adapted to local conditions.

Crotalaria juncea gave the highest dry weight production of the various cover crops under test. *C. striata*, cut at 149 days from planting, gave 7.35 tons of green matter per acre, or 2.1 tons cured. *Tephrosia candida*, cut 266 days after planting, produced at the rate of 5.67 tons of green matter per acre, or 2.61 tons sun dried. Unlike *Crotalaria juncea*, which grows so rapidly that it is well able to hold its own against encroaching weeds, *C. striata* and *Tephrosia candida* grow slowly and in their early development need protection against vegetation of more rapid growth. *T. candida* makes a dense cover and produces strikingly handsome white flowers. Owing to its woody growth, the task of removing *T. candida* from the ground is more laborious than in case of some of the other cover crops.

ROOT CROPS.

During the year the station tested various crops, including sweet potatoes, yams, yautias, and taros, to determine their comparative

yields. In a comparative planting of 34 varieties of sweet potatoes in red clay soil, Key West was the most prolific, giving an average yield of 1.08 pounds per linear foot of row. Pierson (No. 5957⁵) was second and No. 11285 ranked third. Ex-Red Carolina (No. 5970), Early Carolina (No. 5963), Nancy Hall (No. 5966), and Pumpkin (No. 5999), were the least productive of the sweet potatoes. The largest tubers were produced by Dahomey and Porto Rico (No. 21406). The smallest tubers were produced by Early Carolina and No. 7980. Nancy Hall, Mamey, Florida (No. 5950), Key West (No. 5967), and No. 21406 were considered of superior table quality. These and some additional varieties of sweet potatoes are being tested again. A number of imported varieties were distributed by the station.

A test was made with 6 varieties of yams, totaling 244 plants, to learn whether they could be grown without support. The staked yams yielded a little over 385 pounds in comparison with 67 pounds from the unstaked plants. The maximum difference for any one variety was with the Potato yam, the staked vines of which yielded an average of 4 pounds of tubers per plant as compared with an average yield of 12 ounces from the unstaked vines. The minimum difference in any one variety was greater than 3 to 1. Staking affected not only the weight of the total production of each plant, but also the size of its tubers. The unstaked plants produced no large tubers, and of the tubers produced a large proportion were too small to be marketed. The available data from the yautia and taro planting of the last ten years were reviewed during the season and the less desirable varieties were eliminated from the tests.

PLANT INTRODUCTION.

During the year the plant *Talinum verticillatum* was introduced into Porto Rico from the Philippine Islands where it had been imported from Java. This is an upright perennial herb, having tender, fiberless, and succulent leaves that are used like spinach. It is propagated readily from cuttings and grows rapidly. Except for the fact that it is rather subject to root disease, this plant seems well adapted to local conditions.

VANILLA.

A root disease, presumably *Fusarium* sp., made such inroads in the vanilla plantings at the station during the year as to necessitate the use of fertilizers on the plats. Remedial measures are being tried but they are apparently not very promising. Calculations of the time requisite for curing vanilla beans were made from the recorded data on more than 10,000 pods. Two per cent of the pods were con-

⁵ These numbers are Arlington Farm accession numbers.

sidered cured or sufficiently dry for storage within three weeks after picking. From the fourth to the tenth week the percentages were 8, 14, 29, 16, 13, 11, and 4, respectively. The remaining 3 per cent of pods required between 10 and 16 weeks to cure.

A common practice in some vanilla-growing countries is to "needle" the beans at the beginning of the curing process. This consists in making shallow full-length slits on the three sides of the pods with a pen point or with two pins or needles inserted in a small cork or wooden holder. Needling was tried on several lots in the curing of the 1920 crop, and was followed by alternate sunning (exposure to the sun) and sweating (closely wrapping the beans in blankets). The drying was greatly accelerated by needling, but in appearance the product was less glossy or oily than the check lot and did not keep as well. The lot which was needled to a depth of a little less than one-sixteenth inch by two pins set one-sixteenth inch apart, was reduced by the ninth day to 27 per cent of its original weight. The check lot at this time was reduced to only 69 per cent. The needled beans were no longer exposed to the sun, but those in the check lot required sunning for a period of from 6 to 11 days longer. The needled beans were sufficiently dry for storage in from 14 to 16 days after needling, while those in the check lot required from 5 to 17 days longer.

COFFEE.

The cooperative experiment for the control of the coffee-leaf disease (*Stilbella flavida*), begun in 1917, was concluded during the year and the data were submitted for publication.⁶

In a cooperative fertilizer test on coffee, nitrate of soda, applied semiannually for five years, failed to cause any increase in the crop. The plan of the experiment was therefore changed to compare nitrate of soda with sulphate of ammonia. In a planting of 60 coffee trees at the station farm, the plat which received the sulphate of ammonia made four times as great a yield as did that which received the nitrate of soda. Prior to this there had been six semiannual applications of fertilizer furnishing equivalent amounts of nitrogen in the two forms. As the trees were young and in short rows of five each and the plats consisted of alternate rows, conditions were very uniform for the two plats under comparison.

COCONUTS.

The cooperative experiment begun in 1915 to determine the effect of fertilizers on the growth of young coconut palms was continued

⁶ Porto Rico Sta. Bul. 28, "The Coffee Leaf Spot (*Stilbella flavida*) in Porto Rico," copies of which may be had by addressing the agronomist in charge of the station.



FIG. 1.—FIVE-YEAR OLD MAHOGANY TREES.

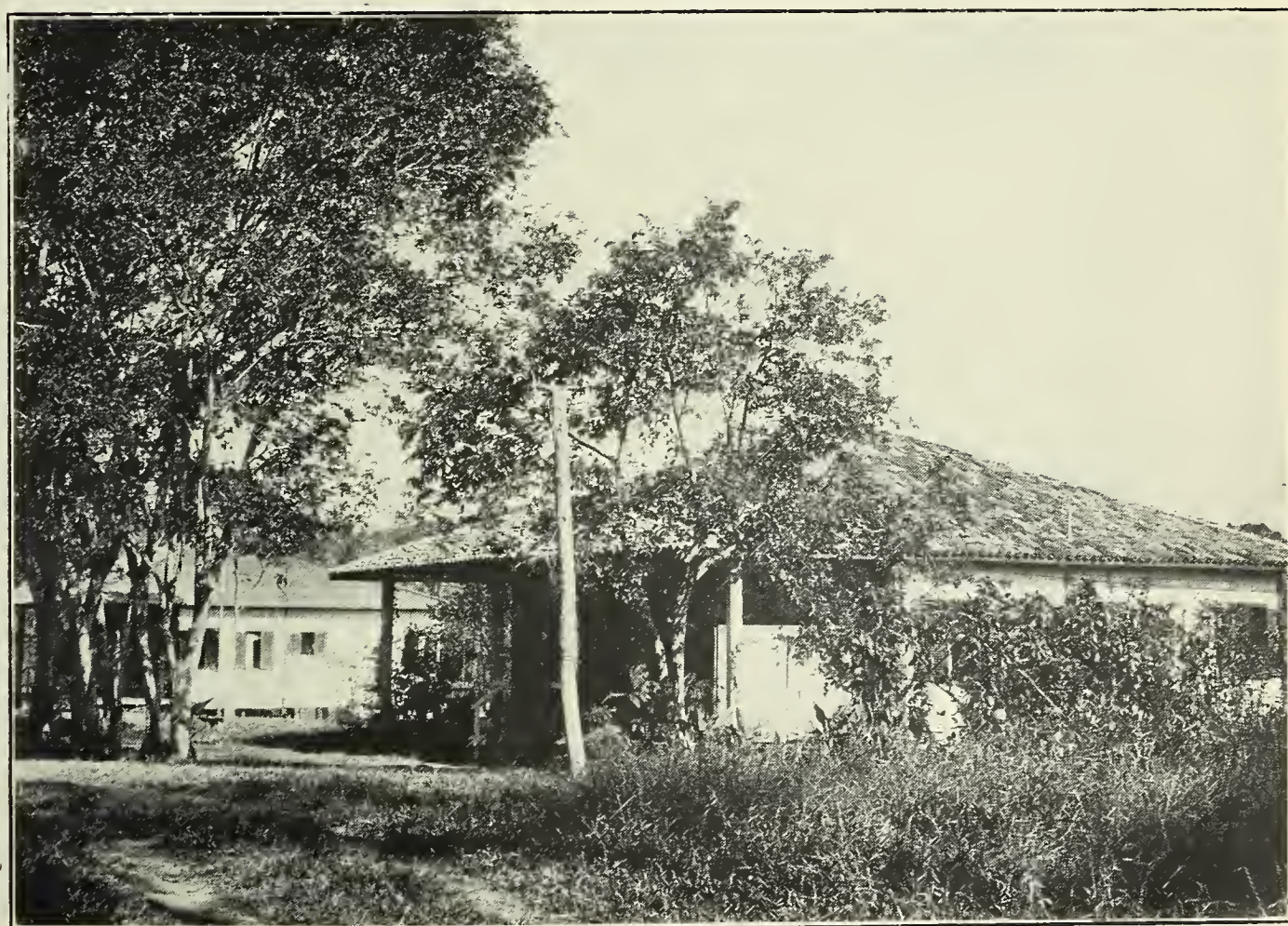


FIG. 2.—HOUSES CONSTRUCTED FROM LUMBER FROM ARMY CANTONMENT.



FIG. 2.—KENTIA PALM.



FIG. 1.—MANGO GRAFTED ON STUMP.

during the year, plats of 10 trees each again receiving semiannual applications of complete and incomplete mixtures of chemical fertilizers, as well as tobacco stems, stable manure, and seaweed in combinations with chemical mixtures. During the first 18 months of production the best yield was made by the plat to which common salt (sodium chlorid) only had been applied. Nine trees in this plat have matured nuts, while only two have done so in the check plat. From four to five trees have fruited in each plat which received incomplete fertilizer, and from four to nine trees in each plat which received complete fertilizer. Salt has been found to be so beneficial that it will be tested on a much larger scale in an old coconut grove where records have been kept of the individual yields of several hundred trees for over eight years.

MANGOES.

Among the imported mangoes in the station orchard are a number of varieties which have never fruited. Some of these are large trees which were planted 16 years ago; others are younger trees of sufficient size and age to fruit, but fail to do so. In an attempt to induce fruiting, a number of these unproductive varieties and a few of the younger trees were girdled. The test included 37 trees of 17 varieties. From one to four limbs on each tree were girdled between November 30 and December 2, 1920, a band of bark about three-quarters of an inch in width being removed from each. The limbs selected ranged chiefly from 6 to 10 inches in circumference. The cambium in various instances had practically filled in the cut area four months after girdling, but it did not in any instance re-establish a connection between the girdled branch and the tree. About 9 per cent of the limbs had bridged the cut area in six months. Blossoming was induced only on two specimens of the youngest trees girdled, these being 6 or 7 years of age. One of the two specimens also blossomed and fruited on an untreated limb, but the other, Chempadan, blossomed on the girdled limb only. None of the other trees blossomed at all, either on the girdled or the untreated limbs. Among the older trees the branches of which were girdled on from three to six of each variety, were the varieties Mulgoba, Madras, Bombay Yellow, and Bombay Green. These four and a number of other Indian varieties give only small promise of fruiting in this locality unless a means can be found to induce blossoming. The Cambodiana or Chinese mango fruited well during the year. The record of a number of years indicates that the Cambodiana is one of the leading imported varieties for this locality, both in regard to quality and to production. The planting and observation of Cambodiana seedlings will be continued. From these plantings compari-

sons may be made between the produce of the several seedlings springing from a polyembryonic seed.

The station is continuing to urge the propagation of some of the better varieties of introduced mangoes, and it has been very successful in grafting them to stumps of inferior sorts (Pl. IV, Fig. 1). Recently the growing of ornamental palms for shipment to the States has developed into a promising industry. Some of these ornamentals have proved well adapted to Porto Rican conditions (Pl. IV, Fig. 2).

REPORT OF THE PLANT BREEDER.

By THOMAS BREGGER.

GENERAL WORK.

The principal crops upon which work was commenced during the year included corn, rice, soy beans, cowpeas, beans, vanilla, and certain forage grasses.

Corn.—The work with corn was largely a matter of growing selections of native varieties for crossing inter se and with varieties imported by the Office of Foreign Seed and Plant Introduction of the Bureau of Plant Industry, United States Department of Agriculture,⁷ from the mainland and from Turks Islands. Reciprocal crosses were obtained between the varieties Hickory King, Eureka, and a yellow flint from Henderson, and native Porto Rican yellow dent corn. These crosses were made in the spring of 1921 and have not yet matured sufficiently for planting. Certain selections of native yellow dent and a yellow flint variety from Turks Islands were crossed in August, 1920. During the winter dry season a few plants of some of these latter crosses were grown under irrigation, and second-generation plants are now growing in the field. In July, 1920, a cross was obtained between Henderson's Astor sweet corn and native yellow dent. The first generation plants were grown during the past winter under irrigation, and the second generation recessives are now growing in the garden. In appearance these plants are intermediate between sweet corn and field corn, tasseling and silking earlier than the native field corn parent and a bit later than the sweet corn parent. These plants have not yet matured their seed. During the winter the varieties Stowell's Evergreen and De Rue's Golden Giant were planted, together with several strains derived from Guatemalan sweet corn that was obtained from the Office of Crop Acclimatization and Adaptation Investigations, Bureau of Plant Industry, United States Department of

⁷ Copies of Porto Rico Sta. Circ. 18, "The Selection of Seed Corn in Porto Rico," issued in September, 1920, may be had by applying to the agronomist in charge of the station.

Agriculture. With the exception of one strain that was obtained by crossing a Black Mexican with a Guatemalan variety, the sweet corn was a failure. In this case, reciprocal crosses were obtained with an F_1 hybrid of native with Turks Islands yellow flint. The first generation plants of these reciprocal crosses are now growing in the garden and their seed should be available for growing under irrigation this coming winter. It is hoped to develop from these crosses a strain of sweet corn which will be better adapted to the lowlands of Porto Rico than are the present varieties introduced from the mainland.

In January, 1921, some selections were made in a field of Porto Rican corn on the south coast, near Lajas. With these selected ears it is intended to start an ear-to-row cooperative experiment, having for its purpose the isolation of better yielding strains of corn adapted to the region, and the demonstration of the greater value of seed selection in the field over crib selection.

Rice.—On the resignation of the agricultural technologist, W. A. Mace, in July, 1920, the work on rice, carried on in cooperation with the Office of Cereal Investigations, Bureau of Plant Industry, United States Department of Agriculture, was turned over to the plant breeder. Notes were completed on heading, tillering, and yields of 149 selections planted in 17-foot nursery rows by Mr. Mace. A few plants of Honduras and Wataribune, obtained from the Office of Cereal Investigations, and six selections of native rice were grown in pots in the greenhouse. Attempts to cross them met with small success, only 8 viable seeds out of a total of 533 pollinations being produced. It is hoped that with improvements in technique and manipulation better results will be obtained in the future.

Kidney beans.—A planting was made of red kidney beans that were bought on the local market as "Americana." Mass and individual selections of this variety were made and will be continued.

Soy beans and cowpeas.—The station is continuing to make selections from the soy-bean varieties Mammoth, Virginia, Haberlandt, and Hahto, and from the cowpea varieties New Era, Brabham, and Groit. In the past four or five years the soy-bean varieties introduced and tried at the station have included the Mammoth, Chiquita, Virginia, Haberlandt, Wilson Five, Tokio, Bachet, and Hahto, and the cowpea varieties Groit, Brabham, Early Buff, Early Catjang, California Blackeye, Forty-Day Blackeye, Whippoorwill, New Era, Iron Conch, and Monetta. The reduction in the number of varieties tested may be ascribed in part to unfitness of all but four varieties of soy beans and three varieties of cowpeas, and in part to the fact that all the seed of the other varieties was distributed throughout the island. Trial of the above-mentioned varieties will be continued with seed

obtained from the Office of Forage Crop Investigations, Bureau of Plant Industry, United States Department of Agriculture.

Forage grasses.—To determine their comparative yield for forage purposes, Guatemala grass (*Tripsacum daniellii*), Napier or elephant grass (*Pennisetum purpureum*), Job's-tears (*Coix lachryma-jobi*) from the Philippines, teosinte (*Euchlana mexicana*), and Zwinga cane (*Saccharum officinarum*) have been planted in small plats that are uniform in texture, surface, and fertility.

Vanilla.—During the year several crosses were made between *Vanilla planifolia* and *Vanilla* sp. of Venezuela. *V. planifolia* is subject to a root disease which does considerable damage. *Vanilla* sp. of Venezuela apparently is not attacked, or at least it is not injured by the disease.

STORING SEED.

To keep seed viable over periods of unfavorable weather, especially ear remnants in ear-to-row breeding, the station has been making use of 5-gallon oil cans fitted with milk-can lids. Fresh unslaked lime is put in the containers with the seed and the cans are then made air-tight with paraffin. While this method is proving very useful at the station, it is only a makeshift. What is needed is an air-tight room wherein large quantities of seed can be stored. Such a room should be constructed so as to remain perfectly dry for an indefinite period.

REPORT OF THE ASSISTANTS IN PLANT BREEDING AND HORTICULTURE.

By W. P. SNYDER and J. A. SALDAÑA.

SUGAR CANE.

The first plantings of the station's seedling canes of 1919 were made in five-hole lots in April, 1920, and the first harvesting was done during March and April, 1921. Thirty-one of the harvested seedlings were saved for further testing at the station, and some of the cuttings were sent for trial to the Pagán Central, at Añasco.

Notes were taken on the varietal characters and degree of resistance to the mottling disease of the seedlings of the different parents for comparative purposes. It was observed that the seedlings of cane variety D. 109 differed from those of cane variety P. R. 260 in degree of resistance to the mottling disease and in habit of growth. The seedlings of cane varieties D. 109 and Java 36^s averaged

^s The Java 36 referred to is No. 36 P. O. J., the seedlings of which were grown at the experiment station, East Java.

higher in resistance to the mottling disease than did the seedlings of the other varieties, as will be seen from the following table:

Summary of observations made on original seedling canes in March, 1920.

Name of parent.	Average resistance to mottling disease of seedling plants.	Average sucrose content of seedling plants.	Habit of growth.	
			Number of erect plants.	Number of plants inclining and trailing.
	<i>Per cent.</i>	<i>Per cent.</i>		
P. R. 260.....	2.28±0.038	13.62±0.116	111	49
D. 109.....	3.33±.060	12.92±.116	29	56
P. R. 317.....	2.13±.095	13.57±.334	8	7
G. C. 1480.....	2.21±.175	15.36±.339	5	10
Java 36.....	3.63±.093	12.40±1.250	5

It is thought that the number of seedlings produced by cane variety Java 36 is too small to warrant the drawing of conclusions. The influence of the habit of growth of the parent varieties is very evident in the large number of erect-growing seedlings that were obtained from cane variety P. R. 260.

The degree of resistance to the mottling disease was obtained by grouping the seedlings into the following classes: (1) Severely diseased, (2) diseased, (3) slightly diseased, (4) very slightly diseased, and (5) not diseased.

When the assistant in plant breeding was reappointed after an absence from the station of 10 months, the station had no good pollen-producing varieties that were old enough to arrow the following winter. Germination in most of the seed boxes was therefore very unsatisfactory. A fair germination was obtained from a number of arrows of cane variety D 117, which was obtained from the Guánica Central fields near Añasco. Two other factors handicapped the work: The practically complete failure to germinate of all arrows that were bagged, the result, most probably, of too high a temperature within the bags, as noted by Barber,⁹ or to injury to the stalks; and the death of approximately two-thirds of the seedlings shortly after they were transplanted to the field, due, no doubt, to their small size at the time of transplanting and the excessive soil moisture. A few arrows of the variety Cristalina, which was obtained from Aguirre Central, produced five seedlings, all of which survived the transplanting. The total number of surviving seedlings is only little more than 200.

The station planting of cane S. C. 12/4, introduced from the Virgin Islands station in 1919, has continued to make vigorous growth,

⁹ Barber, C. A. Sugar Cane Seedling Work in India. Part II. The Internat. Sugar Jour., 22 (1920), No. 258, pp. 307-312.

notwithstanding its having been attacked by the mosaic disease. Cuttings of this cane have been distributed to a number of planters for trial. Several other varieties have since been introduced from St. Croix and from Java for trial at the station.

FIELD CORN.

The object of the work with corn is to isolate some of the different types of native corn, to increase the yield, and to determine the effect on the yield of grain of the selection of different types of plant, ear, and kernel. It is planned to maintain continuous self-fertilization in all lines of selection, as far as possible, with the purpose of ultimately crossing the best self-fertilized strains. Dry weather following the planting of the past season caused the loss of much of the seed, and the plats were replanted with corn that had been imported from Venezuela. The Venezuelan corn produced a vigorous plant growth, but it apparently is not a good yielder of grain, because the plants began to dry when the ears were still small.

Notwithstanding the fact that the station has found the development of some of the acclimated varieties of the island to be the best way to improve the corn crop, it conducted a further test with imported varieties from Queensland for the purpose of selecting the best for hybridization work. The varieties tested included Reid's Yellow Dent, Improved Yellow Dent, Boone County White, and Star Leaming. These four varieties made vigorous growth until the appearance of the silks and tassels, when they were attacked by mosaic disease, followed by a reddening of the leaves and a drying up of the entire stalk. Not an ear was harvested from the whole plat, consisting of approximately half an acre.

SWEET CORN.

A great many varieties of sweet corn from the States have been tried without success at the station year after year. Failure is undoubtedly due to their inadaptability to tropical conditions. The station has, therefore, been endeavoring to produce by hybridization a variety which will have the requisite hardiness to withstand tropical conditions.

A further test for the purpose of selecting the most vigorous variety for hybridization work was made in the spring of 1920 with the varieties Golden Bantam, Stowell's Evergreen, Hiawatha, Pocahontas, Henderson's Astor, and Henderson's Sugar. The last-named variety, being the most vigorous, was selected as the male parent. The mother parent was a white native corn (strain S), which has been grown for some generations at the station and which

is doing well as a field corn. Several crosses were made between these two varieties, and from them a first generation ear was selected for the 1921 planting. Every single kernel, with the exception of 8 out of 81 where mosaic disease appeared, germinated and produced a strong, healthy stalk. This planting was made on April 9, and the silk and tassels began to appear on May 26. Reciprocal crosses were then made between all the healthy plants. Harvesting began on July 7 and ended on August 1. The 61 reciprocal crosses segregated into sweet and starchy kernels. The greater number of the second-generation hybrids showed very promising characters, which will be studied in later generations. A number of the best ears were saved for future planting.

In the hybridization work there occurred two accidental crosses which may be promising. The male parents were evidently yellow native field corn and the St. Croix Blue Hybrid,¹⁰ and the female parent in each case was Henderson's Astor. Some ears, which correspond to the second generation, were saved for planting during the coming season.

WHEAT.

A number of Indian wheats, together with the varieties Regenerated Defiance, Early Baart, Sonora, Bluestem, and Marquis, were planted in a small plat during the winter. The plantings were supplied with a minimum of irrigation in order that observations might be made on the behavior of the wheat under comparative drought conditions. Mixed fertilizer was applied at the rate of 5 grams per 4-foot row. An unusually large amount of rain fell just at the blooming period and facilitated the spread of a fungus disease that considerably damaged the grain.

The Early Baart and Sonora varieties failed to germinate. The varieties Defiance, Bluestem, and Marquis were practically failures, while the Indian wheats gave variable yields, ranging from averages of 10.7 to 54.6 grams per 4-foot row. The season of growth was in most cases very short, ranging from 97 to 145 days, and the texture of the grain, with few exceptions, was rather soft. A few well-filled bearded heads appeared in the plantings of Marquis and Bluestem and were saved for future testing.

TOMATOES.

Several pests handicap the work of growing tomatoes at Mayaguez. Nematodes are present in such numbers that practically all tomato plants grown at the station are heavily infected with root knot.

¹⁰ St. Croix Blue Hybrid is the result of a cross between black Mexican sweet corn and St. Croix native field corn. It was bred by and obtained from the Virgin Islands Agricultural Experiment Station.

The plants, however, manage to produce a fair crop unless they are attacked by some other trouble. A very destructive disease of the tomato plant in Porto Rico is due to the *Cladosporium* fungus, which destroy the leaves and ultimately the whole plant. Spraying will not hold this fungus in check during the rainy season. During the winter a new trouble appeared, causing affected tomato plants to stop growth, the young leaves to partially roll together and stand erect, and the entire plant to become stiff and rigid. This disease was probably superinduced by unfavorable soil conditions. The entire spring crop was affected while in the seed boxes, but overcame the trouble after being transferred to the field and fertilized. During the year a wilt-producing disease attacked the tomato crops at the station and practically destroyed the whole planting. A diseased plant was sent to Washington and examined by W. A. Orton, pathologist in charge of Cotton, Truck, and Forage Crop Disease Investigations, Bureau of Plant Industry, United States Department of Agriculture, who reported no evidence of either *Fusarium* or bacterial wilt, but severe infection by both nematodes and *Rhizoctonia*.

One of the objects of the tomato work is to obtain, if possible, strains that will be resistant to disease. A first generation cross between the Lares Native and Stone varieties showed apparently strong resistance to the trouble last mentioned. Both parent varieties were considerably damaged, but to a less degree than were the majority of the plantings. The tomato crop was not seriously damaged by *Cladosporium* during the year. Injury by this fungus to each variety differed in extent, however, and an effort is being made to select strains which will prove resistant to its attack. Another object of the work is to improve the size and quality of the native tomato by crossing it with commercial varieties. A cross between Insular Station Tomato No. 443 and the Diener, a wilt-resistant variety, has been carried through the second generation, but it is very susceptible to attack by *Cladosporium* and most of the plants are poor yielders. A cross between a native ridged tomato and the Greater Baltimore has also been carried through two generations and gives hope of producing a good fruit. Several other first-generation crosses have been grown. The tomato work of the former assistant horticulturist was taken over in July, 1920, and selections have been made from Insular Station Tomato No. 443 through two more generations. This tomato exhibits much variation, but on the whole the fruits are small, somewhat rough, and rather bitter in flavor. No very marked improvement has been obtained with this tomato.

The greater part of the spring planting consisted of second-generation plants which were the progeny of a cross between the varieties

Greater Baltimore and Native, and between Insular Station Tomato No. 443 and Diener, a California tomato.

MUSKMELONS.

A cross was made in 1919 between the large native muskmelon and the variety Salmon Tint Pollock, which is a Rocky Ford type of melon, and also between the native melon and the A. and M. Hybrid Casaba.¹¹ The native melon is large, oval, late maturing, and somewhat resistant to downy mildew, which is very destructive to the common commercial melons grown at the station. The first and second hybrid generations were grown during the year, the first generation being grown under glass during the rainy season.

Resistance to mildew was evidently not a dominant factor, because the progeny of the crosses was killed sooner than were the native plants that were grown for comparative purposes. The plants of the second generation, grown from native seed, showed evidence of contamination with pollen from the crossed plants, and they could not, therefore, be used as a basis for comparison. When the two commercial varieties were used as parents, however, the planting proved a failure, while most of the hybrid plants produced fairly good melons.

In the first as well as in the second generation plants from self-pollinated seed, a perplexing variety of shapes was produced, including oval, ovate, globular, and pear-shaped fruits. The inheritance of season of maturity was evidently intermediate in the first generation and showed great variation in the second generation. Netting did not show up until the second generation, with the exception of a few traces at the stem end of the first-generation fruits. The second generation of the Salmon Tint Pollock cross exhibited all degrees of netting, from completely smooth fruits to heavily netted ones. Of the first-generation fruits of this cross, 10 had green flesh and one had pale yellow flesh. Nine out of twelve second-generation plants produced green-fleshed fruits, and three produced fruits with more or less yellow flesh. All the fruits of the Hybrid Casaba cross had deep yellow flesh in the first generation, and six out of seven in the second generation were also yellow fleshed. The seventh plant produced fruit having white flesh. The edible quality was poor in the first generation, because the fruits were not properly developed, and in the second generation all degrees of quality were obtained. Further selection will be made with the aim of obtaining desirable types of high-quality fruit adapted to Porto Rican conditions.

¹¹ The letters "A" and "M" are the initials of the seedmen from whom the varieties were obtained.

A trial planting was made on the station grounds on the Mesa back of Mayaguez of the varieties Hero of Lockinge, Blenheim Orange, Sutton's Superlative, Rocky Ford, Berry, Flat Jenny Lind, Large Hybrid Casaba, Honey Dew Casaba, and the native melon. Good fruits were produced by the varieties Rocky Ford, Berry, Honey Dew, and the native melon. The English varieties were failures. All the plants received commercial fertilizer, and half of the planting was treated with about a pound of rotted manure per plant, while the other half was left without manure. The effect of the manure was very noticeable, the plants which were not treated making poor growth and producing only a few undersized fruits.

BANANAS.

A planting made in 1919 of Chamaluco bananas selected for resistance to the Panama disease did very poorly. Only one bunch had been produced by the spring of 1921, and most of the plants showed unmistakable symptoms of Panama disease. These plants were removed from the plat, and a few of the most vigorous were chosen for replanting, together with a number of apparently healthy suckers from an old plat of unselected plants. A number of slightly diseased suckers were planted for purposes of comparison. A fertilizer experiment was started on part of the plat to ascertain the effect of wood ashes and tobacco stems on the Panama disease. An experiment was begun in September, 1918, to compare the effects of lime, ashes, acid phosphate, cyanamide, tobacco stems, stable manure, and rice straw as fertilizers, and of *Centrosema plumerosa*, cowpeas, and black velvet beans as cover crops. After two years, an examination made of the amount of disease injury under the different treatments gave no conclusive results.

MISCELLANEOUS WORK.

It has been impossible to undertake further work with grapefruit. About 300 2-year old seedlings from crosses between the Duncan and Triumph varieties are being grown. A planting has been made of Hawaiian, Mexican, and native papaya plants with the purpose of improving the yield and quality of the fruits by cross-breeding. On the Mesa back of Mayaguez a fall planting was made of white clover, Peruvian alfalfa, and white sweet clover. The white clover was a failure. The alfalfa and sweet clover have made a fair growth where both acid phosphate and lime were applied to the soil. A spring planting of sweet clover is making good growth.

REPORT OF THE ENTOMOLOGIST.

By W. V. TOWER.

MOTTLING DISEASE OF SUGAR CANE.

The mottling disease of cane is still causing heavy losses in Porto Rico. Many of the new seedlings and practically all of the native varieties are infected. A number of experiments have been carried on by the station to determine whether this disease is transmitted by insects. Young cane often shows a secondary infection which is apparently the work of insects, but so far the station has not been able to determine what insect, if any, causes it. Seventy-six potted seedlings were under observation during the year, not one of which developed the mottling disease as the result of transmission by insect. The station did not limit its experiments to insects which were obtained from infected cane, but also included insects that were taken from native grasses and weeds growing in the cane.

During the spring of 1921 the common yellow plant louse (*Sipha flava*) was very abundant and stunted the growth of cane in many fields. Uba cane especially was in some instances seriously damaged by it. The beneficial insects accompanying the louse were not in sufficient numbers to hold it in check until the rains set in, and as a result whole fields turned yellow and many of the leaves died. Other varieties of cane were affected, but none so seriously as was the Uba cane. The yellow plant louse was found in great numbers on malojillo grass, from which it spread to the cane. In some instances the infection was so heavy that the grass turned yellow and many leaves became brown. The presence of this insect in so many fields infected with mottling disease suggested that the louse might be responsible for the transmission of the disease. Trials were therefore undertaken to determine whether or not this was the case. Insects were transferred to healthy young canes which had been grown in 5-gallon tins and covered with cheesecloth from the time they were set out to protect them from insect attack. These canes were grown from selected seed obtained from the south side of the island, where the disease has been held in check by constant roguing and selection. They were protected from all insects from the time of planting. The cane which was subjected to insects obtained from diseased canes failed to develop the disease. Insects from grasses and weeds that were growing in diseased canes were then transferred to these healthy plants, but in no case did disease develop. The yellow plant louse was found on a number of different plants, including malojillo, grama, yerba dulce, elephant grass, sorghum, orchard grass, corn, wheat, and morning-glories. Insects obtained from all of these plants were transferred to healthy cane. In a number of instances where

field corn showed a peculiar mottling, insects were taken from it and transferred to healthy cane.

In transferring insects to cane two methods were practiced: In the first method, the plant lice were lifted by means of a camel's-hair brush from the diseased cane and placed on the healthy cane. This method was followed only where insects were obtainable, the insects being placed in small bottles fitted with a tube made of wire gauze. These cages were slipped over healthy leaves, or over growing buds or shoots, and enabled one to observe the insects and remove the cheese-cloth without touching them. The collection of moisture in the bottles, however, caused many of the insects to stick to the sides. Doubtless tubes made of wire gauze alone would be better. This method was found satisfactory for the control of such active insects as leafhoppers, springtails, and thrips. In the second method, pieces of leaves harboring large numbers of insects were cut from the infected plants and transferred to the healthy specimens. The lice established themselves in strong colonies on the young growing cane as the leaves died. This method also was tried when springtails, red spiders, and thrips were transferred to cane.

Other insects were tested as carriers of the mottling disease. A number of transfers made of the common green plant louse of corn and sorghum to cane failed to develop the disease. The black thrips of cane and the ever-present springtail were tried many times, but no infection could be attributed to them. Large numbers of leafhoppers in all stages of growth were transferred from diseased cane and corn to healthy cane, and in some cases the full life history was carried through on the caged cane. The common green sugar-cane leafhopper (*Kolla similis*) was also tried. This insect, as well as a pale yellow straw-colored leafhopper, is frequently found on young cane, and at times is very abundant. The nymphæ of the latter are whitish and are considered a new species by Smyth,¹² who terms them false mottling leafhoppers. A smaller species resembling *K. similis* also appears on cane. It has the same general color as, but is smaller than, *K. similis*. These insects were also transferred. Others tested included the smoky-wing leafhopper, the chocolate-colored specimen having wings transparent at the apex, and the little dark brown hopper having the basal portion of the wing brown and the tip transparent. Strong colonies of the sugar-cane mealybug developed in a number of pots, being brought in from the outside by ants.

Other species tried were *Cicadella* (*Tettigonia*) *sirena*, *Oliarus cinereus*, and the West Indian cane fly (*Stenocranus* (*Delphax*) *saccharivorus*), none of which transmitted the disease. During the

¹² Smyth, E. G. Insects and Mottling Disease. In Jour. Dept. Agr. Porto Rico, III (1919), No. 4, p. 106.

year the only infection in the greenhouse occurred in three pots which were planted with single stools of seedling cane B 6450. When the original stool was taken up and divided it seemed perfectly healthy. The three plants were infested with yellow plant lice (*Sipha flava*) taken from diseased cane, malojillo, and grama grass growing among diseased cane. The same experiments were carried on many times with this yellow plant louse, obtained from diseased cane, malojillo grass, and grama grass, but no infection took place. Doubtless the disease was dormant in the canes when they were taken up and immediately showed itself because the power of resistance in the plants had been weakened by transplanting.

TICKS.

Monthly studies were again carried on with ticks taken from cattle, goats, horses, and dogs. Some of the cattle ticks were kept in the insectary; others were placed in the open in a weather shelter of the standard Weather Bureau type. Efforts to carry the ticks through long periods were much more successful this year than they have been heretofore at this station. The conditions under which ticks are kept have much to do with their longevity. From the data accumulated at the station, it would seem that the starvation period is much longer than was at first thought.

The interest shown in the work of eradicating the tick has been general. A number of privately owned dipping tanks have been constructed and the insular legislature has enacted a law providing for municipal dipping tanks. By the passage of a law making it compulsory to dip the animals at regular intervals, the stock raiser and farmer in Porto Rico should have no difficulty in exterminating the tick. Such an extermination will doubtless encourage many of the stock raisers to import improved cattle.

From July 1, 1920, to June 30, 1921, 1,954 head of cattle were dipped in the vat at the station. This vat is corrected once every three weeks, chemicals being added to increase the strength of the solution or water being added to dilute it. It is cleaned and the solution renewed once every five months. Cattle within a radius of 5 miles are brought to the station for dipping. There are on the island at the present time 98 dipping vats, 19 of which belong to the insular government.

BEE INDUSTRY.

With the decrease in price of honey and wax, there has been a corresponding lessening in the interest formerly manifested in the bee industry. The past season was more favorable for honey production than a year ago, when the island was visited by a severe

drought. Only a few queens are being introduced into Porto Rico and as a result the stock is deteriorating.

MOSQUITOES.

The result of the mosquito survey, made during the fiscal year 1920 and mentioned in the last annual report, has been published as a circular of the station.¹³

REPORT OF THE SPECIALIST IN FARM MANAGEMENT.

By H. C. HENRICKSEN.

THE CITRUS-FRUIT INDUSTRY.

The different lines of investigation of this division were reported upon in detail in the last annual report.¹⁴ Certain of the citrus-fruit investigations, as outlined last year, were continued. The work undertaken to determine the present cost of producing and handling fruit in Porto Rico and to devise methods of reducing the cost was finished during the year; that carried on to obtain data on decay of fruit in transit and to find methods of preventing this decay was practically completed.

Cost of production.—As was stated in last year's report, it is impossible to obtain accurate data on cost of production. The station has prepared, in mimeographed form, an outline of plantation cost accounting, copies of which may be had upon application to the station. This work has been discontinued for the present.

Fruit rot.—The study of decay in transit, concerning which a preliminary report was made last year, was again continued as the main investigation. During November the specialist in farm management stayed in New York to study some phases of the problem by observing the condition of the fruit cargoes arriving from Porto Rico. December was spent principally in Washington, where a study was made of the respiration of fruit. The remainder of the fiscal year was devoted mainly to a study of fruit rot. This investigation included studies of transpiration and respiration, as represented by loss in weight of the fruit, and the relation of this loss to the rotting of grapefruit, the effect of the products of respiration on the development of the decay, means by which fungi gain entrance to the fruit, and the influence of temperature, ventilation, and humidity upon the development of rot.

¹³ Porto Rico Sta. Cir. 20, "Mosquito Survey in Porto Rico," copies of which may be had by applying to the agronomist in charge of the station.

¹⁴ Porto Rico Sta. Rpt., 1920, pp. 27-37.

Practically all the decay of Porto Rico grapefruit is due to the stem-end rot caused by the fungus *Diplodia natalensis*. The fungus does not appear to be able to enter the fruit through the uninjured rind. Normal entrance is through the short stem, when cut, or through the cavity, if the stem is pulled from the fruit. As the disease is nearly always found about the stem, the name stem-end rot has been given it. Other decays follow injuries to the fruit, blue mold being rather common.

The *Diplodia* fungus is present in the orchards, and it may be introduced by the clippers used in harvesting the fruit. On this account the disinfection of the clippers after each fruit is cut from the tree is recommended. This can readily be done by wiping the clippers with a cloth saturated with a corrosive sublimate solution. Sealing with shellac the cut end of the stem or the cavity where the fruit is pulled from the stem has reduced stem-end rot to a considerable extent. Fruit that has been disinfected and shellacked as above described can be kept at room temperatures without developing stem-end rot until it dries up.

Some experimental data were obtained on the proper temperature and ventilation for the shipment of grapefruit, but the problems connected with the commercial handling of the fruit between the orchards in Porto Rico and the market in New York have not yet been solved.

Shipping miscellaneous tropical fruits.—As a result of the investigations on the handling of citrus fruit, a study of the keeping and shipping qualities of other tropical fruits was undertaken during the year. This study will be continued as one of the main projects of the coming year.

AGRICULTURAL EXTENSION NOTES.

Timely information dealing with agricultural subjects continued to be published in the form of Agricultural Extension Notes. Five of the numbers issued dealt with fruits, vegetables, and food crops in general. The others were concerned with ornamentals, cane, coffee, mosquitoes, lime and its uses, and live stock.



The first of these is the fact that the United States is a young nation. It is only about 150 years old, and its history is therefore a history of rapid growth and development. The second is the fact that the United States is a large nation. It covers a vast area of land, and its population is one of the largest in the world. The third is the fact that the United States is a diverse nation. It is made up of many different peoples, races, and religions, and this diversity has been one of its strengths.

The fourth is the fact that the United States is a free nation. It is a nation in which the people have the right to speak their minds, to assemble peacefully, and to participate in the government. The fifth is the fact that the United States is a democratic nation. It is a nation in which the people elect their representatives, and these representatives make the laws and run the government. The sixth is the fact that the United States is a peaceful nation. It has never been at war with another country, and it has always been a champion of peace.

The seventh is the fact that the United States is a powerful nation. It has a large and strong army, a powerful navy, and a strong economy. The eighth is the fact that the United States is a nation of opportunity. It is a nation in which anyone can succeed if they work hard and have the right opportunities. The ninth is the fact that the United States is a nation of progress. It is a nation that is always moving forward, always seeking to improve itself and its society. The tenth is the fact that the United States is a nation of hope. It is a nation that believes in a better future, and it is always working to make that future a reality.

THE UNITED STATES OF AMERICA

The United States of America is a country in North America. It is the third largest country in the world by area, and the third most populous. It is a federal republic, and its capital is Washington, D.C. The United States is a member of the United Nations, the North Atlantic Treaty Organization, and the Organization for Economic Cooperation and Development.

The United States is a country of many different peoples, races, and religions. It is a country of many different languages, and it is a country of many different customs and traditions. The United States is a country of many different cities, towns, and villages, and it is a country of many different landscapes and climates.

The United States is a country of many different people, and it is a country of many different dreams. It is a country of many different hopes, and it is a country of many different futures. The United States is a country of many different people, and it is a country of many different dreams.

